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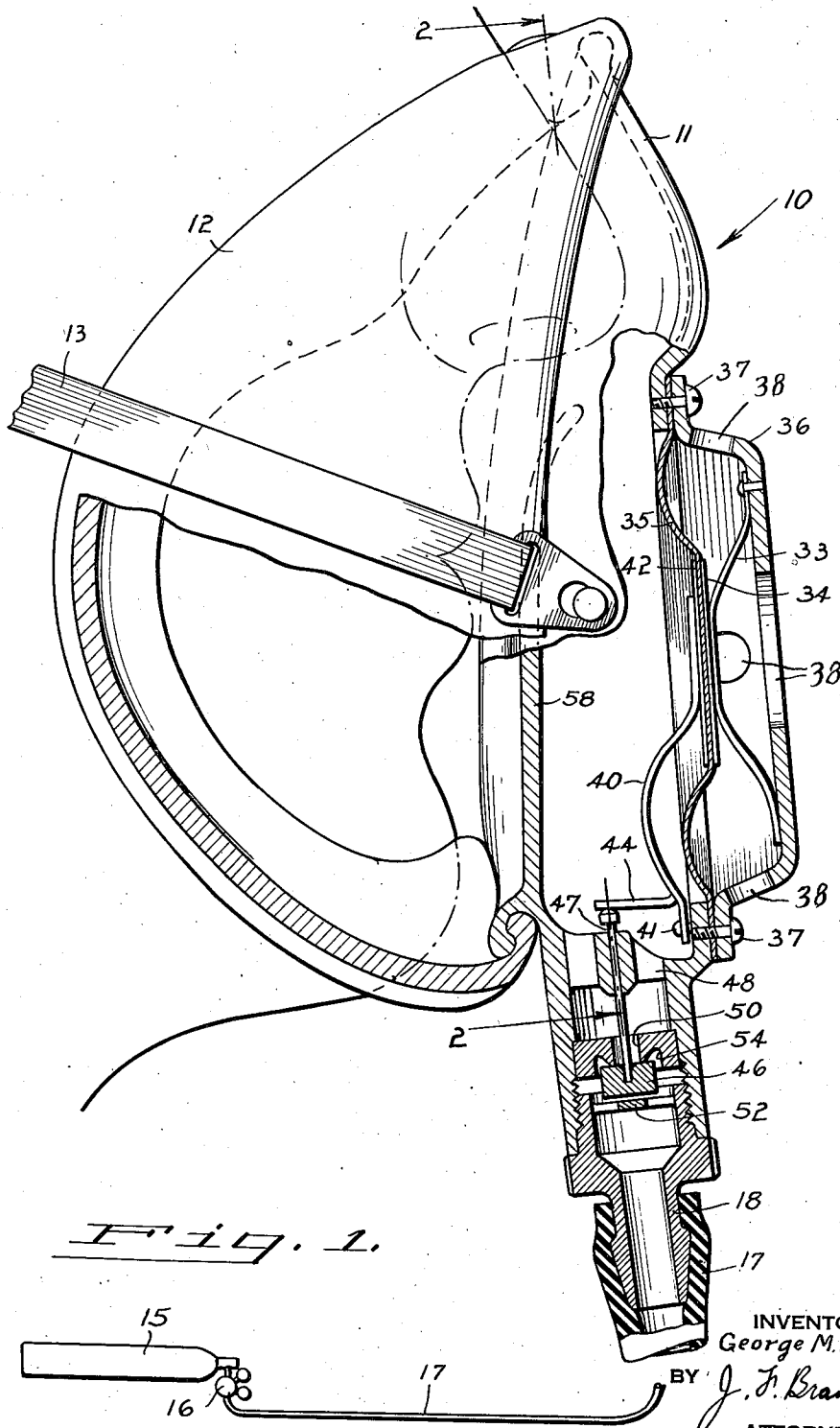
G. M. DEMING

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BREATHING APPARATUS

Filed April 3, 1941

2 Sheets-Sheet 1



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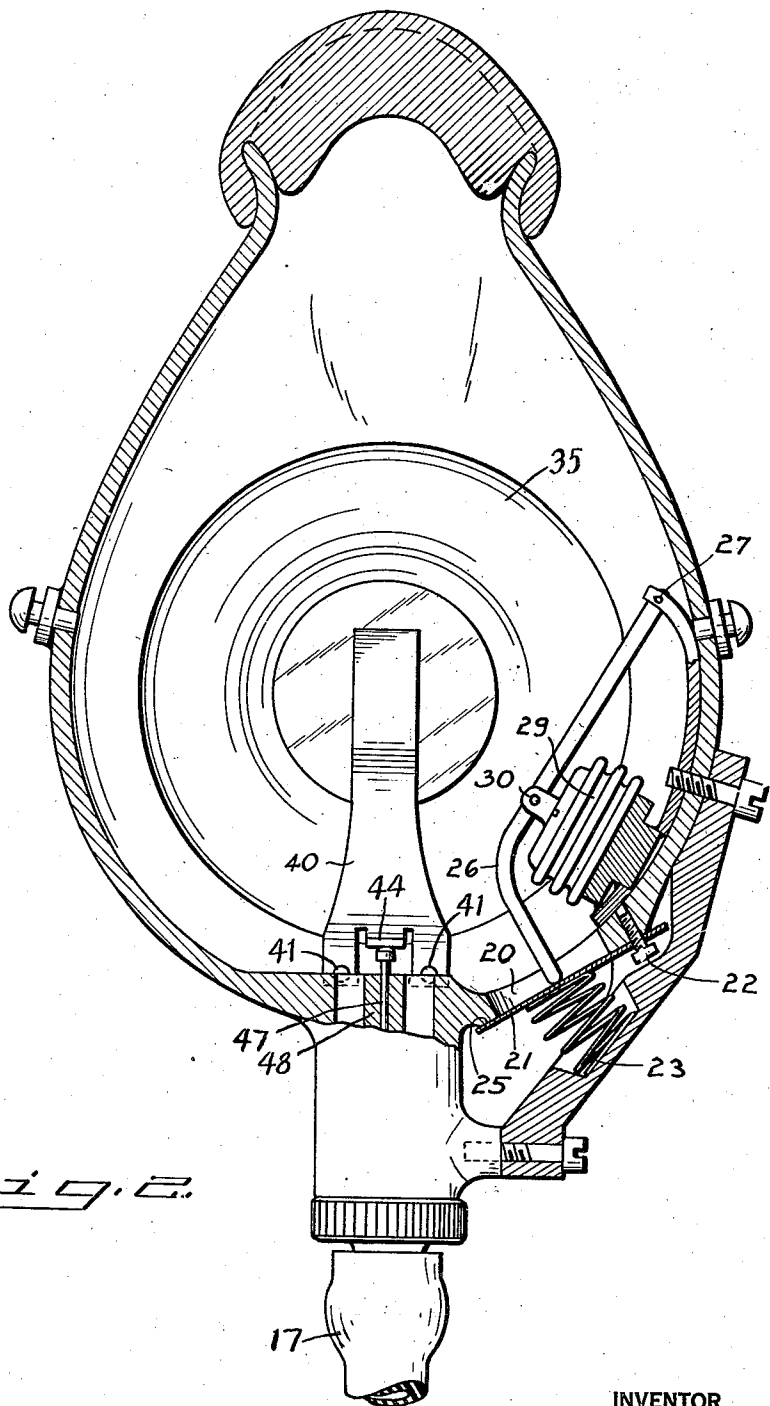


Fig. 2.

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BREATHING APPARATUS

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Application April 3, 1941, Serial No. 386,618

9 Claims. (Cl. 128—142)

This invention relates to breathing apparatus, and more especially to apparatus for supplying oxygen to aviators at high altitudes, though some features of the invention can be used with other apparatus for administering gas generally.

When supplying oxygen to aviators, the proportion of oxygen must be increased as the altitude becomes greater, until at very high altitudes the aviator breathes pure oxygen. Manual control means were formerly employed to change the oxygen supply in accordance with the needs of the aviator, but such a control of the oxygen supply is unreliable and may at times be dangerous.

In order to obtain more reliable variation in the oxygen supply with changes in altitude, apparatus was developed in which a flow of oxygen was regulated by aneroid control means. With such a control the oxygen is entirely shut off at low altitudes and the apparatus opens progressively as altitude increases.

It is an object of this invention to provide an improved breathing apparatus in which the supply of oxygen is automatically controlled in accordance with the altitude. It is a feature of the invention, however, that instead of supplying predetermined quantities of oxygen at the various altitudes, the oxygen supply is made dependent upon the requirements of the individual aviator.

This result is attained by supplying only as much oxygen as is necessary to maintain the pressure in a breathing mask at the pressure of the surrounding atmosphere. Air can enter the mask through an opening that leads to the surrounding atmosphere, but the amount of air that enters the mask in this way to dilute the oxygen is decreased by means of an aneroid-controlled valve. In this way the proportion of oxygen supplied to maintain the pressure in the mask is progressively greater as the altitude increases.

There are a number of advantages in controlling the supply of oxygen in the manner employed by this invention, because the oxygen for any given altitude varies greatly according to the size, mental state and physical activity of the individual. It has been ascertained, for example, that a flow rate may be set which is entirely adequate to meet the physiological requirements of the individual and yet if the individual takes a sudden deep breath, as a result of excitement or possibly because of lack of familiarity and therefore confidence in breathing by means of an oxygen mask, the failure to take into his lungs as much oxygen as the lungs require when suddenly distended, is very likely to alarm the wearer

or at least greatly retard his satisfactory adaptation to mask breathing. With this invention there is no predetermined supply of oxygen, but the supply of oxygen is automatically replenished during inspiration so as to maintain the pressure in the mask substantially the same as that of the surrounding atmosphere.

With this invention oxygen flows whenever the aviator inhales, but ceases to flow during the process of expiration and intermediate period known as the respiratory pause. Obviously by such an arrangement, a large individual or one who attempts to breathe deeply will automatically be supplied with more oxygen than a small individual breathing normally. It will be obvious that such an arrangement necessarily leads to considerable economy in the use of the oxygen. Tidal volume, that is, the amount of air or oxygen taken into the lungs, varies as much as ten to one according to the size of the individual and the degree of physical activity or respiratory exertion involved. Consequently, unless the flow rate is automatically adjusted to the actual respiratory process, considerable excess oxygen must be supplied.

Except at high altitudes where the aviator must breathe pure oxygen, the interior of the mask communicates with the atmosphere through a valve-controlled opening in the side of the mask. This valve is operated in accordance with changes in the barometric pressure to progressively close the opening so that less air is drawn in to dilute the oxygen as the atmospheric pressure drops off at increasing altitudes.

I have found that it is not sufficient to maintain the pressure in the mask merely approximately equal to the pressure of the surrounding atmosphere in order to give the wearer greatest confidence in the mask. Such can only be attained when any increased effort at breathing is so negligible that it is likely to be ignored even by one who has not previously used an oxygen breathing mask. I find that the pressure difference between the inside of the mask and the surrounding atmosphere should not be substantially greater than that of a one-tenth of an inch water column, and preferably not more than one-half this amount. The improved regulator apparatus of this invention can maintain a pressure in the mask that does not vary more than plus or minus .05 inch of water.

Other objects, features and advantages of the invention will appear or be pointed out as the specification proceeds.

In the accompanying drawings, forming part hereof:

Fig. 1 is a side view, mostly in section, showing an aviation breathing mask embodying the invention.

Fig. 2 is a rear view, mostly in section on the line 2-2 of Fig. 1.

The mask 10 includes a metal shield 11 with a cushion 12 that is filled with soft material, preferably sponge rubber, attached around the edge of the shield for contact with the face of the wearer. The mask is held against the face by means of an elastic band 13. Because of the extremely slight differences between the pressure in the mask and that of the surrounding atmosphere it is not so important that the mask fit tightly against the wearer's face.

The mask is connected with a source of oxygen, such as a cylinder 15, shown diagrammatically in Fig. 1. Oxygen is supplied, through a pressure regulator 16 that reduces the pressure to approximately three pounds per square inch, to a soft rubber tubing 17 that connects with a nipple 18 at the bottom of the mask.

The interior of the mask is in communication with the surrounding atmosphere through an air port 20 (Fig. 2) that opens through the side of the mask and is controlled by a valve comprising a thin, light-weight disk 21. This valve is of the flap type, being secured to the mask at one side by a screw 22 and the valve disk is lightly loaded by a very delicate valve spring 23. The disk 21 may be made of a thin lamination of mica.

At sea level, the valve disk 21 is held away from its seating surface 25 by means of a valve lever 26. The upper end of the valve lever 26 is connected to the mask by a pivot 27 that serves as the fulcrum of the lever 26. An aneroid bellows 29 is secured in a fixed position in the mask and is connected to the valve lever 26 by a pivot 30. The parts are so proportioned and the stiffness of the bellows 29 so selected that with decreasing pressure surrounding the bellows, that is, with increasing altitude, the bellows will expand gradually and lift the lever 26 so that the separation between the valve disk 21 and its seating surface 25 is gradually decreased. In practice the operation is such that the air port 20 is completely closed by the valve disk 21 when an altitude of 33,000 ft. is reached.

The air port 20 is used both as an admission port and as an exhaust port. During expiration, the expired air presses upon the valve disk 21 so as to overcome the force of the spring 23, and opens the valve regardless of the position of the lever 26. It will be understood, however, that a separate exhaust valve controlling an exhaust port can be provided if desired. The mask is simplified, however, by using the same port and valve both for exhaust and for the admission of air to dilute the oxygen.

The mask includes pressure-regulator apparatus for controlling the supply of oxygen into the mask. A regulating spring 33 presses against a bearing disk 34, which may be made of paper and secured to the front of a diaphragm 35. The edge of the diaphragm 35 is clamped between the metal shield 11 and a front cover 36 that is fastened to the shield by screws 37. There are openings 38 in the cover 36 for exposing the front of the diaphragm 35 to the pressure of the surrounding atmosphere.

A regulating valve lever 40 is connected to the mask by means of two loosely fitting fulcrum pins 41 and has a head 42 against the back of the

diaphragm 35. Hence, any inward thrust upon the diaphragm 35 and the head 42 of the regulating lever 40 results in a downward thrust of a toe 44 of the lever 40. This downward thrust is communicated to a valve 46 through a thrust pin 47 which slides freely in a drilling in a wall 48.

The valve 46 controls passage of gas through a port 50. The thrust pin 47 is in axial alignment with the port 50 and the lower end of this thrust pin 47 fits into a central socket in the top face of the valve 46. The fit of the thrust pin 47 in the socket of the valve 46 is loose enough to permit the valve to rock slightly on the end of the thrust pin and thus insure tight closure of the valve 46 when the diaphragm 35 moves and the valve 46 is forced upward by the pressure of the gas beneath it.

The valve 46 has a face that is flat and smooth, and is preferably made of material that requires very little compression to effect a gas-tight closure. Soft rubber is suitable if of a grade that is sufficiently flat and smooth, though metal can be used. The lip against which the valve 46 seats is metal.

When the apparatus is not in use and there is no gas pressure under the valve 46, the spring 33, acting through the lever 40 and thrust pin 47, pushes the valve 46 as wide open as possible, but the maximum opening of this valve 46 is limited by a stop 52. I have found that the pressure of oxygen in the mask can be made independent of the demand rate by restricting the flow of the gas to the port 50. The flow is restricted by limiting the lateral or peripheral clearance between the valve 46 and the surrounding wall 54. The pressure above the valve 46 gradually increases with increasing rates of discharge, that is, with increasing displacements of the valve 46 from the lip against which the valve 46 seats at the end of the port 50.

In effect, the restriction offered by the proximity of the wall 54 to the periphery of the valve 46 insures that with increasing rates of discharge the pressure drop from the region upstream from the valve 46 to the region immediately downstream from the restriction is great enough to compensate for the increased counter-reaction of the pressure against the top surface of the valve 46. This feature of the invention is not limited to aviation masks, or even to breathing apparatus.

The regulating spring 33 is preferably made sufficiently weak so that oxygen flows into the mask when the pressure in the mask is slightly less than the atmospheric pressure, for example at a pressure about .05 of an inch of water below the pressure of the surrounding atmosphere. As long as the pressure within the mask is above that level, no oxygen will be discharged to the mask. Hence, as long as air can be inspired through the clearance between the flap valve 21 and its seat 25 without creating a pressure differential greater than .05 of an inch of water, no oxygen is supplied to the mask. If, however, the aneroid 29 has caused the valve 21 to close sufficiently, there are periods in each respiratory cycle when more or less oxygen flows into the mask through the port 50.

The mask can be used with a rebreathing bag if the spring 23 is made stiff enough to cause a pressure rise upon expiration sufficient to inflate the bag. The connection for the rebreathing bag can communicate with the interior of the mask

through a side wall or any other port where an opening of sufficient size can be provided.

A baffle 58 (Fig. 1) is provided to protect the diaphragm 35 and the regulator mechanism.

Changes and modifications can be made in the various elements and combinations described without departing from the invention as defined in the claims.

I claim:

1. Aviation breathing apparatus including in combination a face mask with an inlet opening and an exhaust opening, an oxygen supply line communicating with the inlet opening, a pressure regulator comprising a valve at the inlet opening and valve-operating means responsive to the difference between the pressure within the mask and the pressure of the surrounding atmosphere, said valve-operating means being sensitive to a pressure differential not substantially greater than one-tenth of an inch of water, an exhaust valve over the exhaust opening, an aneroid device for holding the exhaust valve open at low altitudes, and a light loading spring urging the exhaust valve closed, said spring being of such a nature that it yields to permit the exhaust valve to open in response to an excess of pressure within the mask.
2. In a breathing apparatus for aviation, a mask, a pressure regulator for controlling the supply of oxygen to the mask, an exhaust valve for the mask, and aneroid control means for the exhaust valve.
3. The combination with an inhaler for an aviator, of a pressure regulator for controlling the supply of oxygen to the inhaler, said regulator including means responsive to a cessation of inspiration by the aviator for shutting off the oxygen supply, an exhaust valve, and an aneroid device for holding the exhaust valve at least partially open at low altitudes.
4. Aviation breathing apparatus including a mask open at the back with a rim shaped to fit against a wearer's face, a large opening and two smaller openings in the wall of the mask, a valve commanding the first of the smaller openings, motion-transmitting connections within the mask and supported from the wall of the mask for operating said valve, an exhaust valve commanding the other of the smaller openings and constructed and arranged to open outwardly for the exhaust of gas from within the mask, a diaphragm closing the large opening in the wall of the mask and exposed on one side to the outside atmosphere, said diaphragm being secured to the mask around the entire edge of said large opening so that when the mask is worn, the diaphragm, mask wall, and face of the wearer form a reduced-pressure chamber of a pressure regulator, an operative connection between the diaphragm and said motion-transmitting connections within the mask, means for connecting an oxygen supply line to the mask in position to communicate with said chamber through the first of said smaller openings, and means responsive to changes in atmospheric pressure for mechanically opening said exhaust valve various amounts in accordance with changes in altitude.
5. Aviation breathing apparatus comprising a mask, means for supplying oxygen to the mask including an inlet port through which oxygen flows into the mask, a flexible diaphragm forming a part of one side of the mask exposed on the inside to the pressure in the mask and on the outside to the pressure of the surrounding atmosphere, a valve supported by the mask and

commanding the inlet port, and opening against the pressure of the oxygen supply, said port having a hard lip against which the valve seats, a thrust pin for opening the valve, said thrust pin having one end loosely fitting in a socket in the valve, motion-transmitting connections in the mask and between the diaphragm and the thrust pin for opening the valve when the pressure outside the mask exceeds that within the mask, a light regulating spring on the atmosphere side of the diaphragm, means for the escape of gas from the mask including an exhaust valve comprising a light, thin flap valve supported on the mask and opened by a slight excess of pressure in the mask, and a delicate spring urging the exhaust valve closed.

6. Aviation breathing apparatus including in combination a regulator that receives oxygen at high pressure and delivers the oxygen at a reduced pressure, a flexible tubing, a face mask connected to the pressure regulator by said flexible tubing, a second pressure regulator within the mask for admitting oxygen from the tubing into the mask only when the pressure within the mask is below a predetermined relation to the pressure of the surrounding atmosphere, an exhaust valve for the escape of excess pressure from the mask, and means responsive to changes in atmospheric pressure for holding said exhaust valve open various amounts in accordance with changes in altitude.

7. Breathing apparatus comprising a face mask having an inlet port and an exhaust port, a valve that commands the inlet port and opens against the pressure of the incoming oxygen, a diaphragm that forms a part of the side of the mask, a spring urging the diaphragm to flex inward, motion-transmitting connections within the mask between the diaphragm and the inlet valve for opening the inlet valve as the diaphragm flexes inwardly, and another valve commanding the exhaust port and movable independently of the inlet valve.

8. An aviation breathing mask having an oxygen port, an air port, and a large opening closed by a bellied diaphragm, a light spring urging the diaphragm to flex inwardly, a valve at the inlet port, a valve stem for thrusting the valve against the pressure of the incoming gas to open said valve, a light bell-crank in the mask between the diaphragm and valve stem for displacing the valve stem when the diaphragm flexes inwardly, another valve commanding the air port, and an aneroid control device on the mask for controlling the opening of the air port valve in response to changes in altitude.

9. The method of supplying oxygen to a breathing mask, which method comprises supplying oxygen to the mask when the pressure within the mask is slightly less than the pressure of the surrounding atmosphere and only when the pressure is less than that of the surrounding atmosphere, establishing, independently of the oxygen supply, communication between the interior of the mask and the surrounding atmosphere whenever the pressure in the mask exceeds that of the surrounding atmosphere, and maintaining said communication between the interior of the mask and the surrounding atmosphere during inspiration to dilute the oxygen within the mask, and obstructing said communication by various amounts to control the concentration of the oxygen in the mask.

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